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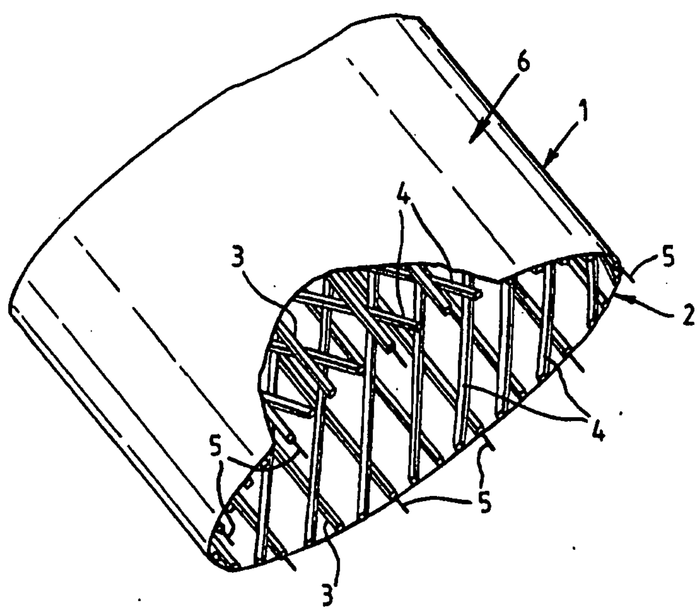

(57) Abstract

A land drain (1) to be used for the electrokinetic drainage of soil is made by integrally extruding a biplanar mesh structure tube (2) of electrically–conducting plastics material so that the tube (2) is of trellis construction. Every alternate longitudinal outer strand (3) contains a tinned copper wire (4) which is passed through the stationary outer die of the die head as the respective strand (3) is extruded. The tube or core (3) so formed is wrapped with a suitable drainage filter fabric (6).

Electrically-Conducting Element

Background of the Invention

The present invention relates to electrically-conducting elements and particularly but not exclusively those for placing in contact with the soil, eg inserted into or embedded in the soil. The use of electrokinetic effects in geoengineering constructions is known and such use is described on pages 9 to 18 in a paper by C J F P Jones et al entitled "Geosynthetic Materials with Improved Reinforcement Capabilities" and published in the Proceedings of I.S. Kyshu '96, November 12 - 14 1996, Fukuoka, Japan. A current is caused to flow through the soil between suitable electrically-conducting elements acting as an anode and a cathode. When the current is passed, there is a flow of water to one of the elements, and that element can be formed as a drain so that the water is drained off. Land drains can be thin drains or wick drains, which are flat tape-like drain constructions, for instance either being formed of a laid-flat biplanar mesh structure tube with filter fabric wrapped around it or of corrugated plastics material with filter fabric wrapped around it. The main use of electrokinetic effects is in the consolidation of the soil and increase in strength by reducing the water content, but the effect can be employed to clean contaminated land, some contaminants flowing with the water flow and being flushed out - there is a description of removing contaminants in WO 95/21965. There are other uses for suitable electrically-conducting elements, such as for an earthing element. In addition, the electrically-conducting element can be employed to reinforce the soil, extending for instance horizontally through the soil above another electrically-conducting element which is also extending horizontally through the soil. In a different application, suitable electrically-conducting elements can be used to provide electromagnetic or antistatic shielding which can be around equipment in any position, whether above the ground or below.

The term "soil" as used herein can refer to earth or ground, and can be of any suitable form, such as rocks, stones, gravels, sands, clays, mine spoil or slag.

The Invention

The invention provides methods according to Claims 1 or 26 and elements according to Claims 10 or 27. There is extended electrical contact between the wire and the soil when the element is placed in contact with the soil, which contact can be directly between the bare or uncovered wire or for instance by way of an electrically-conducting plastics material covering the wire. The amount of electrical contact will depend upon the proposed conditions of use. There could be electrical contact along at least about 50% of the whole length of the wire in that part of the element which is in contact with the soil, but for instance it may be sufficient to have only about 1% or about 5% of the length of the wire directly in electrical contact with the soil or in contact with the electrically-conducting plastics material, provided that the parts so in contact are relatively short and fairly evenly distributed along the length of the wire. If two elements are being used, one as an anode and one as a cathode, a 2.5 mm or 10 mm length of wire so in contact every 50 mm along the wire may be sufficient if the elements are 1 m or 2 m apart, or, more generally, the spacing of the parts of the wire so in contact along the wire is desirably less than the order of magnitude of the spacing between the two elements. In one embodiment however, the wire will be exposed between every two adjacent strands that the wire crosses, and in another embodiment the wire will be in electrical contact with an electrically-conducting plastics material at least each time the wire crosses an electrically-conducting strand. The invention also provides methods according to Claims 2, 3 or 4 and elements according to Claims 11, 12 or 13.

Available plastics materials which are electrically conducting are of high electrical resistance so that only a low current density can be passed; compared with using such plastics material alone, the use of the wire of the invention provides the major financial advantage of the cheap production of an electrically-conducting element of sufficiently high conductivity.

In a preferred arrangement, the invention provides a geoengineering construction, comprising soil and at least one element of the invention. The element can be a drain and/or an earthing element, and/or the element can reinforce the soil. The electrically-conducting wire of the element can be electrically connected to a source of electrical potential difference. If the element is acting as an anode, negative pore water pressures in the vicinity of the element can instantaneously increase a bond between the element and the soil. In the use of the element in the soil, one can achieve electromigration (charged ions moving in solution), osmosis (liquid containing ions moves) or phoresis (charge particles move).

In the case of electromagnetic or antistatic shielding, the electrically-conducting plastics material contributes to or forms the major part of the shielding - however the wire improves the shielding and provides a good conductor eg for earthing.

The wire can be mono-filament or multi-filament. The wire can be of any suitable conducting material. Tinned copper has the advantage of being readily solderable to a power supply wire at any point along its length. Stainless steel has the advantage that electrical contact can be made by mechanical clamping and is particularly useful in general engineering and geoengineering because of its corrosion resistance. Other materials include copper, aluminium or galvanised steel. Due to the electrochemical effect, the actual material can influence the effect achieved. If a suitable metal, eg stainless steel, is used, the electrically-conducting element can also be used as a soil reinforcing element, normally with the wire(s) extending in the direction of expected maximum tension.

The wire can be incorporated when making the element so that the wire is engaged by molten or softened plastics material and is retained by the plastics material when the plastics material sets. Preferably, when making an element comprising a mesh structure having strands, the wire is passed through the same orifice as a strand, and in general the wire can be embedded in or more generally extend along the strand. If the wire is surrounded by the plastics material, the plastics material should be electrically conducting if electrical contact is required with soil. An advantage of the plastics

material is that it provides corrosion protection for the wire. Due to the plastics material being engaged with or around the wire, it provides a large flow-cross-section for the electrical current passing between the wire and the soil. However, it could be arranged that the wire is exposed in a multiplicity of parts along its length. When making an extruded element, the wire can be inserted in the element without passing through an extrusion orifice or passing through the side of an extrusion orifice (when the wire may be on one side of a strand), when the wire will be exposed between every two adjacent strands that the wire crosses; if the wire is passed through an extrusion orifice, its position can be regularly oscillated from say a position in the centre of the orifice to a position at the side of the orifice; alternatively, the wire can be passed through an orifice in the extrusion head with no plastics material supply. If the wire is exposed, it may have only a short life (days or perhaps weeks) as an electrokinetic anode in geoengineering due to accelerated damage caused by electrochemical actions, but this may be acceptable in certain situations.

If the wire runs along a strand, the wire cross-section is preferably not less than about 10% of the strand cross-sectional area; the wire cross-sectional area is preferably not greater than about 60% of the strand cross-sectional area; the wire cross-sectional area is preferably about 20 to 50% of the strand cross-sectional area. The strand cross-section is that of the plastics material and the wire as measured half-way between crossing points of the mesh.

It is preferred that the wire(s) be in the strands of only one set, for economy and ease of manufacture. Even in the one set, it is preferred that there be not a wire in each strand - for instance, the wires can be in alternate strands or in every third or fourth strand.

All the plastics material of the mesh structure may be electrically conducting, to give a uniform distribution of electrical current in the soil or a uniform degree of electromagnetic shielding, but this is relatively expensive and may be weaker. If cost and/or strength are of importance, it is possible that just one set of strands (that associated with the wires) or just those strands along which the wires run be electrically conducting.

The mesh structure can be formed in any suitable way, but the preferred ways are in accordance with GB 836 555 or GB 969 655. For making land drains, the former is preferred, the mesh structure being extruded as a tube with the strands in adjacent planes: the tube is laid flat and is surrounded with a suitable filter material. The four layers of strands in the lay-flat material gives complex drainage passages where at any point water is able to flow in multiple directions, reducing the risk of localised blockage; also, if ground movement or poor installation takes place and the drainage element is kinked in the ground, the four-layer nature can ensure continuation of a drainage path even through the kink. The preferred construction is a trellis mesh construction as in Figure 20 of GB 836 555.

Preferred Embodiments

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic isometric drawing of a first land drain in accordance with the invention, not in its fully-flat state;

Figure 2 is a schematic isometric drawing of a second land drain in accordance with the invention, not in its fully-flat state;

Figure 3 is a schematic isometric drawing of a geoengineering construction in accordance with the invention;

Figure 4 is a vertical section through another geoengineering construction in accordance with the invention; and

Figure 5 is a vertical section through an enclosure in accordance with the invention.

Figure 1

Figure 1 illustrates a land drain 1 which has a core 2 formed by integral extrusion in accordance with Figure 20 of GB 836 555. The core 2 is a tube of biplanar integrally-extruded plastics material, comprising longitudinal outer strands 3 and helical inner strands 4, thus forming two sets of strands 3, 4 at an angle to each other and crossing each other, the sets being interconnected where they cross. Every alternate longitudinal strand 3 has a wire 5 running approximately along its axis, the wire 5 thereby being embedded in the strand 3 and surrounded by the plastics material of the strand 3. The plastics material of the strands 3 is electrically conducting. The core 2 is wrapped in a suitable filter fabric 6. For use, the drain is completely flattened.

Figure 2

The land drain of Fugure 2 is exactly the same as that of Figure 1, except that the wires 5 have been passed through respective extrusion orifices in the diehead with no plastics material supply so that the wires 5 are partly exposed; however the wires 5 are partly embedded in plastics material where they cross the inner strands 4, which secures the wires 5 in position.

Figure 3

Figure 3 illustrates a geoengineering construction with soil 11 containing two electrically-conducting drains 1, eg as in Figure 1 or 2. The cores of the drains 1 are connected in any suitable manner, for instance by clamping or by soldering, to a supply 12 of current so that the right-hand drain 1 acts as a cathode and the left-hand drain 1 acts as an anode. Water will flow from the anode to the cathode, as indicated by the arrow.

Figure 4

Figure 4 illustrates an earth embankment 21 having two layers 22, 23 of electrically-conducting mesh structure embedded therein, the bottom layer 22 being of square-mesh construction and containing electrical wires extending across the embankment 21, and the top layer 23 being of drain construction generally as in Figure 1 or 2. The layers 22, 23 are connected to an electrical supply so that the bottom layer 22 acts as an anode and the top layer 23 acts as a cathode. Water flows upwards towards the top layer 23, which is a drain, and is drained off. Alternatively, depending on the nature of the soil and the degree of water removal required, the polarity and installation of element types may be reversed, when the water flow would be downwards.

Figure 5

Figure 5 illustrates an enclosure 41 to whose inner surface has been applied a mesh structure 42 to provide electromagnetic shielding. The mesh structure 42 can be made generally as described with reference to Figure 1 or 2, but the mesh structure tube would be slit and opened up to provide a single layer of biplanar mesh structure.

Example 1

An extrusion die head was prepared to enable wire incorporation, the die head having a stationary outer die and a rotating inner die and the extrusion procedure being in accordance with Figure 20 of GB 836 555. The die head was arranged so that a wire was passed through each alternate orifice (slots in this case) in the outer die.

The die was of 63.5 mm diameter and a mandrel of the same diameter was used. The inner and outer dies each had eighteen slots 2 mm wide and 1.5 mm deep and nine wires were passed through the outer die by being introduced into slots (orifices) of the outer stationary die through holes in a stationary die carrier. The wire was of 0.9 mm diameter and was of tinned copper. A trellis net was produced with longitudinal and

helical strands 2.2 mm wide and 1.8 mm thick with a nominal weight of 140 g/m run (the nominal weight is the weight that would have been extruded if there were no wires present), with wires 5 encased in every other longitudinal strand 3. The polymer used was Cabot Plastics "Cabelec 3892", formed of conductive carbon black dispersed in a modified high density polyethylene resin, extruded at recommended extrusion temperatures. The speed of rotation of the inner die and the linear speed of fall-off of the mesh structure were set to give a mesh angle of approximately 30° to the axial direction, which is believed to give the optimum combination of mesh stability and drainage performance.

The trellis net core so produced was wrapped in "Terram 1000" filter fabric.

Example 2

It would be possible to modify the die head of Example 1 to provide a special die head fed by two extruders, and to make of "Cabelec 3892" only those strands which contain the wires, the remaining strands being made of "Rigidex 5502", a high density polyethylene.

* * * * *

The present invention has been described above purely by way of example, and modifications can be made within the spirit of the invention.

CLAIMS:

1. A method of making an electrically-conducting element for placing in contact with the soil, comprising forming a plastics material mesh structure with at least one electrically-conducting wire incorporated in the mesh structure by engaging the wire with softened or melted plastics material and retaining the wire by the plastics material when the plastics material sets, the element being such that there is extended electrical contact between the wire and the soil along the length of the wire in that part of the element in electrical contact with the soil, when the element is placed in contact with the soil.

2. A method of making an electrically-conducting element, comprising integrally extruding through respective extrusion orifices a plastics material mesh structure comprising at least a first set of parallel strands and a second set of parallel strands at an angle to the first set and thereby crossing the first set, respective strands being interconnected where they cross, and during extrusion introducing at least one electrically-conducting wire so that the wire is incorporated in the mesh structure, the wire being retained by the plastics material but being exposed in at least a multiplicity of parts along its length.

3. A method of making an electrically-conducting element, comprising integrally extruding through respective extrusion orifices a plastics material mesh structure comprising at least a first set of parallel strands and a second set of parallel strands at an angle to the first set and thereby crossing the first set, respective strands being interconnected where they cross, and during extrusion introducing at least one electrically-conducting wire so that said wire extends along a strand of the mesh structure, the plastics material of at least one strand along which a said wire extends being electrically-conducting.

4. A method of making an electrically-conducting element, comprising integrally extruding through respective extrusion orifices a plastics material mesh structure

comprising at least a first set of parallel strands and a second set of parallel strands at an angle to the first set and thereby crossing the first set, respective strands being interconnected where they cross, and during extrusion introducing at least one electrically-conducting wire so that the wire is incorporated in the mesh structure, at least one said strand which is in contact with the wire being electrically-conducting.

5. The method of any of Claims 1, 2 and 4, wherein the wire extends along a strand of the mesh structure and the plastics material of the respective strand is electrically conducting.

6. The method of any of Claims 2 to 5, wherein the or each wire is extruded through the same orifice as a said strand.

7. The method of any of the preceding Claims, wherein the wire extends along and at least partly within a plastics material strand of the element.

8. The method of any of Claims 1 and 3 to 6, wherein the wire is embedded in a strand of the mesh structure and is surrounded by the plastics material of the strand.

9. The method of any of the preceding Claims, wherein all the plastics material of the mesh structure is electrically conducting.

10. An integrally-extruded electrically-conducting element for placing in contact with the soil, the element comprising a plastics material mesh structure and in the mesh structure at least one electrically-conducting wire which was incorporated when making the mesh structure and is retained by the setting of softened or molten plastics material, the element being such that there is extended electrical contact between the wire and the soil, along the length of the wire in that part of the element in electrical contact with the soil, when the element is placed in contact with the soil.

11. An electrically-conducting element comprising at least a first set of parallel plastics material strands and a second set of parallel strands at an angle to the first set and thereby crossing the first set, respective strands being interconnected where they cross, and at least one electrically-conducting wire incorporated in the element and extending parallel to a said strand, the wire being retained by plastics material of said strands and the wire being exposed in at least a multiplicity of parts alongs its length.

12. An electrically-conducting element comprising at least a first set of parallel plastics material strands and a second set of parallel plastics material strands at an angle to the first set and thereby crossing the first set, respective strands being interconnected where they cross, and at least one electrically-conducting wire incorporated in the element and extending along a said strand, the plastics material of at least one strand along which a said wire extends being electrically-conducting.

13. An electrically-conducting element comprising at least a first set of parallel plastics material strands and a second set of parallel plastics material strands at an angle to the first set and thereby crossing the first set, respective strands being interconnected where they cross, and an electrically-conducting wire incorporated in the element and extending parallel to a said strand, at least one said strand which is in contact with the wire being electrically-conducting.

14. The element of Claim 13, wherein the wire is incorporated in the mesh structure during extrusion.

15. The element of any of Claims 10, 11, 13 and 14, wherein the wire extends along a strand of the mesh structure and the plastics material of the respective strand is electrically conducting.

16. The element of any of Claims 10 to 15, wherein the wire extends along and at least partly within a said strand.

17. The element of Claims 10 to 15, wherein the wire is embedded in a said strand and is surrounded by the plastics material of the strand.

18. The element of any of Claims 10 to 17, wherein all the plastics material of the mesh structure is electrically conducting.

19. The element of any of Claims 10 to 18, and being a drain core having filter material around it.

20. A geoengineering construction, comprising soil and at least one element of any of Claims 10 to 19 in contact with the soil.

21. The construction of Claim 20, wherein the element is a drain.

22. The construction of Claim 20 or 21, wherein the element is an earthing element.

23. The construction of any of Claims 20 to 22, wherein the element reinforces the soil.

24. The construction of any of Claims 20 to 23, with the wire of the element electrically connected to a source of electrical potential difference.

25. A construction comprising at least one element of any of Claims 10 to 18, which element provides electromagnetic or antistatic shielding.

26. A method of making an electrically-conducting element, substantially as herein described in one of the foregoing Examples or with reference to Figure 1 or Figure 2 of the accompanying drawings.

27. An electrically-conducting element substantially as herein described in one of the foregoing Examples or with reference to Figure 1 or Figure 2 of the accompanying drawings.

28. A construction substantially as herein described with reference to Figure 3 or Figure 4 or Figure 5 of the accompanying drawings.

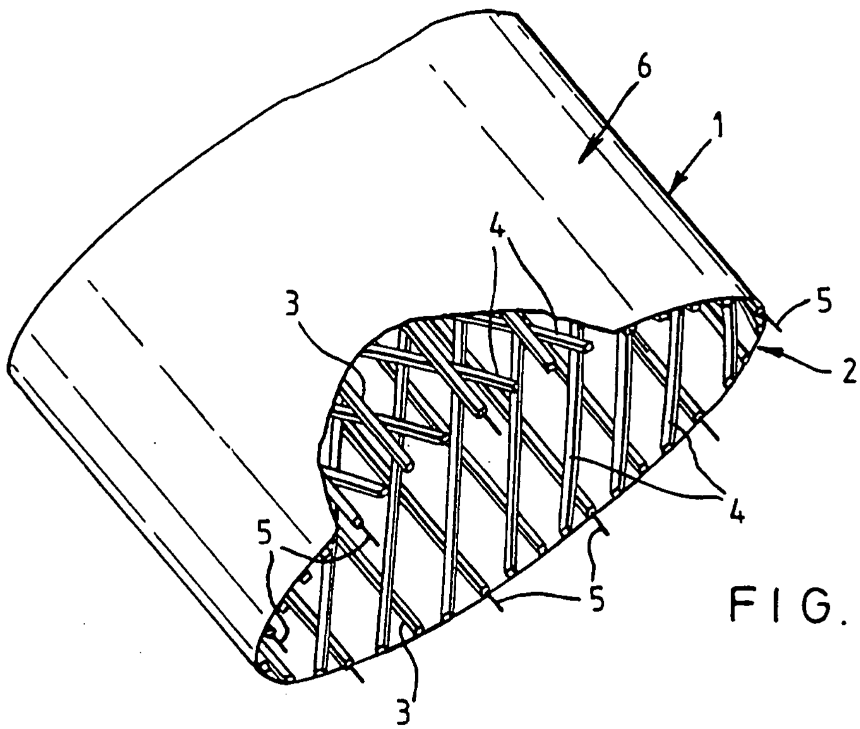

FIG.1

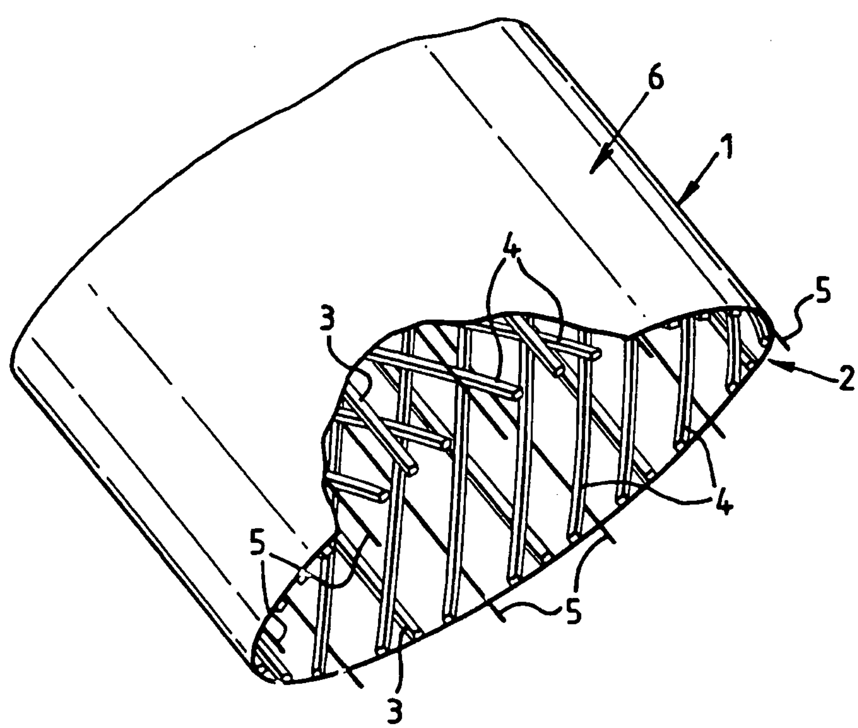

FIG.2

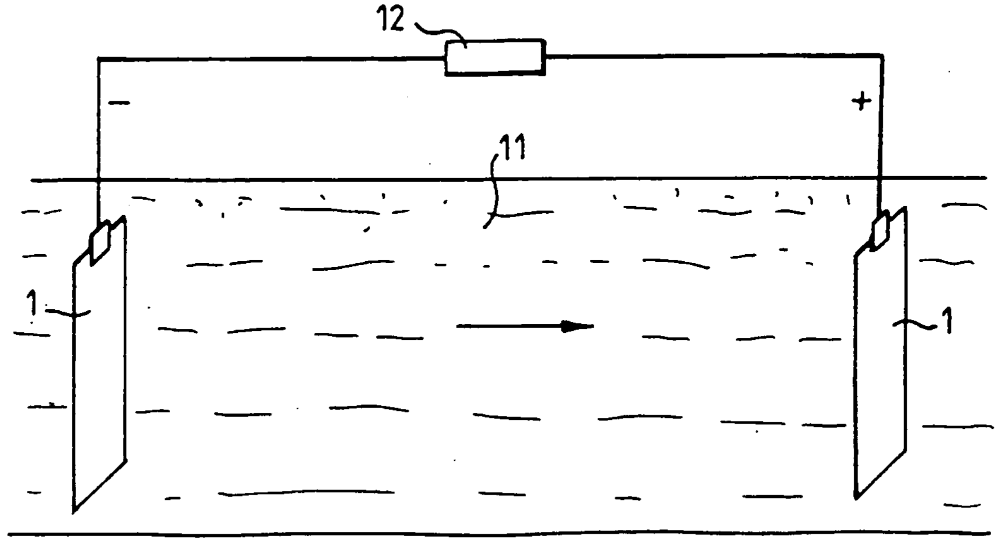

FIG.3

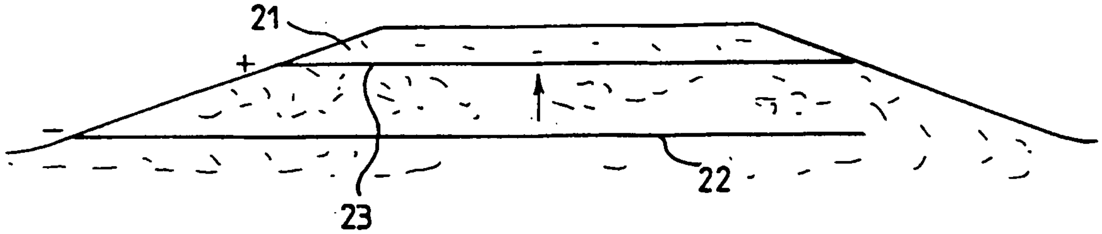

FIG.4

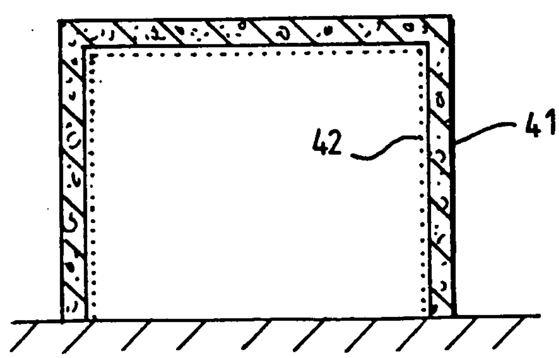

FIG.5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/01841

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E02D3/11 E02D31/02 B29D28/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E02D B29D A01G G01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 96 33313 A (KIM JONG CHUN) 24 October 1996 see the whole document	1-4, 10-13, 20,21, 23,26-28
A	EP 0 087 663 A (NOGLER & DAUM ELTAC) 7 September 1983 see page 21, line 33 - page 23, line 22; figures	1-4, 10-13, 26-28

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 October 1998	21/10/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Internatio Application No
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